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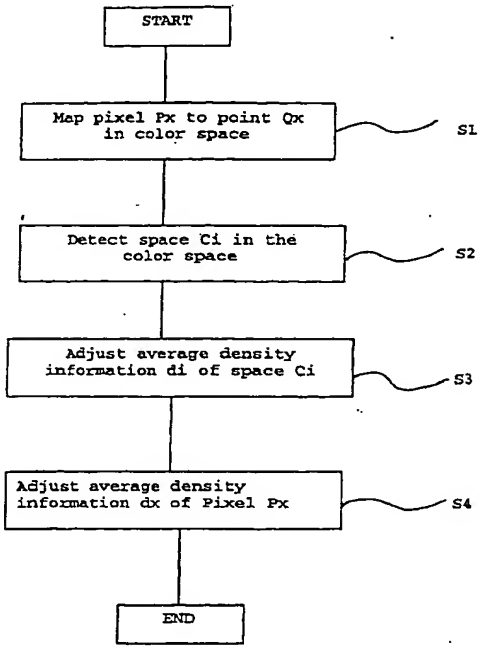
(54) System for processing photographic images

(57) An apparatus and method for automatically adjusting density information of pixels contained in image data is disclosed. The image processing method includes the steps of dividing the image data into a plurality of regions based on color information of the pixels contained in the image data and adjusting density information of the pixels contained in at least one particular region among the plurality of regions.

Fig. 2



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Description

[0001] This invention relates to a system for processing a photographic image, and particularly to an image processing method and apparatus for automatically adjusting the density information of pixels contained in an image data set.

[0002] Conventionally, a photograph is provided by printing an image onto photographic paper where the image has been shot on a film using a camera. The film (specifically, a negative film) has exposure characteristics and these characteristics have some margin or variations considering the varied conditions at the time of shooting. However, the photographic paper on which the image will be printed does not have such exposure characteristics. Accordingly, an image appearing in the film may not appear exactly on the printing paper.

[0003] For example, in case of photographing a person's figure where the background contains a window into which bright sunlight shines, it is difficult to print both the person's figure and the background with appropriate densities. This is because if it is desired to print the person's figure on the photographic paper using an appropriate density, the background is likely to be whited out due to under exposure. Alternatively if it is desired to print the background on the photographic paper with an appropriate density, the figure is likely to be blacked out due to over exposure.

[0004] Previously, an operation called "masked printing" has been necessary for printing both the person's figure and the background onto the photographic paper when the film is shot using the conditions described above. This operation requires a high level of printing skill since it varies the light exposure of one part of the photographic paper from another part by exposing one part of the photographic paper while masking the other part. Accordingly, masked printing has a problem in that it should be done by a manual operation using experts and thus it is expensive.

[0005] Also, there is a problem that, if a film is photographed in conditions where it is under exposed or over exposed, it is necessary to appropriately adjust the duration for printing the photographed image on the film to obtain a good photograph print.

[0006] It is an object of the present invention to provide an image processing method and an image processing apparatus that makes the masked printing technique unnecessary by automatically adjusting the density information of the pixels containing the image data.

[0007] Further, it is another object of the present invention to provide an image processing method and apparatus that makes it unnecessary to adjust the duration for printing an image even when the image or part of the image is photographed with conditions where it is under exposed or over exposed.

[0008] An image processing method of the present invention comprises the steps of dividing the image data into a plurality of regions based on color information of pixels contained in the image data; and adjusting the density information of the pixels contained in at least one particular region among the plurality of regions, whereby the above objects are achieved.

[0009] Another image processing method of the present invention is an image processing method for processing image data containing a plurality of pixels and comprises the steps of mapping the plurality of pixels into a plurality of points in color space, based on color information for each of the pixels; detecting a plurality of spaces contained in the color space, in accordance with the concentration of the plurality of points in the color space; adjusting the average density information of at least one particular space among the plurality of spaces; and adjusting density information of pixels contained in the particular space, based on the average density information of the particular space, whereby the above objects are achieved.

[0010] The step of adjusting the density information of the pixels may further comprise the step of adjusting the density information of pixels contained in a portion of the image data corresponding to an over exposed portion or an under exposed portion of a film.

[0011] An image processing apparatus of the present invention comprises means for dividing image data into a plurality of regions based on color information of pixels contained in the image data; and means for adjusting the density information of the pixels contained in at least one particular region among the plurality of regions, whereby the above objects are achieved.

[0012] Another image processing apparatus of the present invention is an image processing apparatus for processing image data containing a plurality of pixels and comprises means for mapping the plurality of pixels into a plurality of points in color space, based on the color information for each of the pixels; means for detecting a plurality of spaces contained in the color space, in accordance with the concentration of the plurality of points in the color space; means for adjusting the average density information of at least one particular space among the plurality of spaces; and means for adjusting density information of pixels contained in the particular space, based on the average density information of the particular space, whereby the above objects are achieved.

[0013] The means for adjusting the density information of the pixels may further comprise means for adjusting the density information of pixels contained in a portion of the image data corresponding to an over exposed portion or an under exposed portion of a film.

[0014] According to the present invention, based on the color information of pixels contained in the image data, the density information of the pixel is automatically adjusted. The masked printing technique previously used by experts

thus becomes unnecessary.

[0015] According to further aspects of the present invention, the density information of the pixels contained in the portion of the image data corresponding to the under exposed or over exposed portion of the film is automatically adjusted. Thereby, even if the film is photographed with under exposed or over exposed conditions, it becomes unnecessary to adjust the time duration for printing the photographed image onto the photographic paper.

[0016] The above and other objects and features of the present invention will be clearly understood from the following description with respect to preferred embodiments thereof when considered in conjunction with the accompanying drawings, wherein the same reference numerals have been used to denote the same or similar parts or elements, and in which:

Figure 1 is a block diagram showing the configuration of an embodiment of the image processing apparatus according to the present invention.

Figure 2 is a flowchart schematically showing the adjustment processing program.

Figure 3 is a schematic diagram describing mapping pixels P_X to points Q_X in a color space.

Figure 4 is a schematic diagram showing an example of the distribution of the points Q_X in the color space.

Figure 5 is a schematic diagram for describing detection of the spaces C_1 and C_2 in the color space.

Figure 6 is a schematic diagram showing the relationship between the average density information d_i of the space C_i and the new average density information d_i' of the space C_i.

[0017] The general principles of the present invention will now be explained. For automatically using a masked printing technique, it is critical to determine which part of an image is to be masked. Accordingly, for automatically performing masked printing, it is necessary to automatically dividing image data into a region to be provided with a mask and a region that does not need to be provided with a mask.

[0018] This invention uses the color information of the pixels contained in the image data to divide the image data into these regions. The color information of the pixels is represented by a set of components, e.g. red, green and blue that represent the three primary colors.

[0019] A photographed subject (object) can be a solid, for example. Alternatively, if the subject (object) is a plane, it is often photographed with depth. In such cases, the difference in density appears in the object image. For example, shading appears at a spherical surface of a red sphere subjected to light from a certain direction, while the color of the sphere is kept red regardless of the shading.

[0020] Accordingly using such a way of thinking and applying it to colors, it is possible to divide the image data into a plurality of regions. For example, by dividing a region whose color is red and another region that is not, the red sphere can be detected as a circular region.

[0021] A masked printing effect can be achieved by keeping the original density information at a plurality of regions obtained by dividing the image data, while operating on the density information for each of the other regions.

[0022] Also, for a portion of the image data corresponding to an over exposed portion or an under exposed portion of the film, it is preferable to emphasize the image by performing a process that multiplies it with a coefficient having an opposite characteristic to the film characteristic. The embodiments of the present invention will now be described with reference to the drawings.

[0023] Figure 1 shows a configuration of an image processing apparatus 20 of an embodiment of this invention. The image processing apparatus 20 includes an input interface part 21, a CPU 22, a read only memory (ROM) 23, a random access memory (RAM) 24 and an output interface part 26.

[0024] A digital camera 10 is connected to the input interface part 21 of the image processing apparatus 20. The digital camera 10 can be, for example, a CCD camera. The digital camera 10 receives the image photographed on the film and outputs the image data D_1 corresponding to the image. The image data D_1 consists of a plurality of pixels. The image data output from the digital camera 10 is supplied to the CPU 22 via the input interface part 21.

[0025] The CPU 22 performs an adjustment processing program for adjusting the density information of the pixels contained in the image data D_1. The adjustment processing program is stored, for example, in the ROM 23. The RAM 24 is typically a hard disk built in the image processing apparatus 20. The CPU 22, ROM 23 and RAM 24 are all interconnected through a bus 25.

[0026] A digital printer 30 is connected to the output interface part 26 of the image processing apparatus 20. The image data D_1 processed with the image processing program becomes image data D_2 and it is output to the digital printer 30 via the output interface part 26. The digital printer 30 prints the revised image data D_2.

[0027] Figure 2 shows a schematic flow of the adjustment processing program. Each step of the adjustment processing program is performed by the CPU 22.

[0028] In step S1, pixel P_X is mapped into a point Q_X in a color space, wherein the pixel P_X represents an arbitrary pixel contained in the image data D_1. The mapping from the pixels P_X to the points Q_X in the color space will be described below with reference to Figures 3 and 4. In step S2, a space C_i (i = 1, 2, ..., n) in the color space where the concentration of the points Q_X is above a predetermined threshold is detected. Herein, "n" is an arbitrary integer. How to detect the space C_i will be described below with reference to Figure 5.

[0029] In step S3, the average density information d_i is adjusted. In addition, it is preferable to adjust the average density information d_i of the space C_i for all of "i" values. This is done for the purpose of emphasizing the difference in the average density information d_i among the spaces C_i. But, a similar effect can also be obtained by adjusting the average density information d_i of the space C_i for only at least one particular "i".

[0030] In step S4, density information d_X of the pixel P_X is adjusted based on the average density information d_i of the space C_i adjusted in the step S3.

[0031] In this way the density information d_X of the pixel P_X is adjusted. With such an adjustment, the density information for all of the image data D_1 are controlled so that a region with a lighter density becomes denser and a region with more density becomes lighter. As a result, a similar effect as that achieved by manual masked printing can be obtained.

[0032] The mapping from the pixel P_X to the point d_X will now be described with reference to Figure 3.

[0033] The pixel P_X comprises a B value indicating a degree of blue color, a G value indicating a degree of green color and an R value indicating a degree of red color as its color information. In other words, the color information of the pixel is represented with (b_X, g_X, r_X). Herein, b_X represents the B value of the pixel P_X, g_X represents the G value of the pixel P_X and r_X represents the R value of the pixel P_X. Each of b_X, g_X and r_X is an integer, for example between 0 and 255.

[0034] The pixel P_X is mapped to the point Q_X in the color space 40 through mapping F shown in Figure 3. Herein, the point Q_X is a point with coordinates (b_X, g_X, r_X). The color space 40 is a three dimensional space defined with a B axis 42, a G axis 44 and an R axis 46.

[0035] By mapping all pixels P_X contained in the image data into the color space 40, a set of the points Q_X can be obtained.

[0036] Figure 4 shows an example of the distribution of the points Q_X in the color space 40. In Figure 4, spaces C_1 and C_2 indicated with the hatching represent regions with high concentrations of the points Q_X in the color space 40. The spaces C_1 and C_2 correspond to regions A_1 and A_2 with different colors in the image data D_1. This is because the proximity of the points Q_X in the color space 40 are correlated with the similarity of colors in the image data D_1. For example, the region A_1 is a region related to a beige face in the image data D_1, and the region A_2 corresponds to a green mountain in the image data D_1.

[0037] In Figure 4, each pixel contained in the region A_1 of the image data D_1 is mapped into the space C_1 of the color space 40 by the mapping F, and each pixel contained in the region A_2 of the image data D_1 is mapped into the space C_2 of the color space 40. This indicates that the image data D1 is divided at least into the regions A_1 and A_2 based on the color information of the pixels contained in the image data D_1. In this way, the image data D_1 may similarly be divided into N regions based on the color information of the pixels contained in the image data D_1. Herein, N is an arbitrary integer equal to or greater than 2.

[0038] It will now be described specifically how to detect the space C_1 and C_2 in the color space 40 with reference to Figure 5. In Figure 5, a plane 48 is a plane defined with the G axis 44 and the R axis 46. Regions R_1 and R_2 are regions where the concentrations of points Q_X detected are above a predetermined threshold. This is accomplished by examining the distribution of points Q_X along the R axis 46. The regions R_1 and R_2 are defined by the following equations (1).

$$R_1: r_{11} \leq R \leq r_{12} \qquad (1)$$

$$R_2: r_{21} \leq R \leq r_{22}$$

where r_{11}, r_{12}, r_{21} and r_{22} are constants.

[0039] Similarly, regions G_1 and G_2 where the concentrations of points Q_X is above a predetermined threshold. This is accomplished by examining the distribution of the points Q_X along the G axis 44. The regions G_1 and G_2 are defined by the following equations (2).

$$G_1: g_{11} \leq G \leq g_{12} \qquad (2)$$

$$G_2: g_{21} \leq G \leq g_{22}$$

where g_{11}, g_{12}, g_{21} and g_{22} are constants.

[0040] Similarly, regions B_1 and B_2 are regions where the concentrations of points Q_X is above a predetermined threshold. These regions are detected by examining the distribution of the points Q_X along the B axis 42. The regions B_1 and B_2 are defined by the following equations (3).

$$B_1: b_{11} \leq B \leq b_{12} \tag{3}$$

$$B_2: b_{21} \leq B \leq b_{22}$$

where b_{11}, b_{12}, b_{21} and b_{22} are constants. According to the equations 1 thorough 3, the space C_1 and C_2 in the color space 40 are represented by the following equations (4).

$$C_1: r_{11} \leq R \leq r_{12}, \text{ and, } g_{11} \leq G \leq g_{12}, \text{ and, } b_{11} \leq B \leq b_{12} \tag{4}$$

$$C_2: r_{21} \leq R \leq r_{22}, \text{ and, } g_{21} \leq G \leq g_{22}, \text{ and, } b_{21} \leq B \leq b_{22}$$

[0041] A process to adjust the average density information d_i of the space C_i in the step S3 will now be described in detail.

[0042] The average density information d_i is calculated according to the following equations (5). In other words, the average density information d_i is obtained by summing the density information d_X corresponding to all of the points Q_X contained in the space C_i.

$$d_i = \Sigma_{QX \in Ci} d_X \tag{5}$$

$$d_X = (b_X + g_X + r_X) / 3$$

[0043] Variation Δd_i is calculated according to the following equation (6).

$$\Delta d_i = (T - d_i) \times K \tag{6}$$

where T represents a predetermined constant indicating a target value, and K represents a predetermined coefficient. T is, for example, a registered center value of a monitor. The color information (b_X, g_X, r_X) of the pixel P_X is updated into new color information (b_X', g_X', r_X') according to the following equations (7).

$$b_X' = b_X + \Delta d_i \tag{7}$$

$$g_X' = g_X + \Delta d_i$$

$$r_X' = r_X + \Delta d_i$$

[0044] New density information d_X' of the pixel P_X corresponds to the new color information (b_X', g_X', r_X') according to the following equations (8).

$$d_X' = (b_X' + g_X' + r_X') / 3 \tag{8}$$

[0045] Further, new average density information d_i' of the space C_i corresponding to the new color information (b_X', g_X', r_X') is calculated according to the following equations (9).

$$\begin{aligned} D_i' &= \Sigma_{QX \in Ci} d_X' \\ &= \Sigma_{QX \in Ci} \{(b_X' + g_X' + r_X') / 3\} \\ &= \Sigma_{QX \in Ci} \{(b_X + \Delta d_i + g_X + \Delta d_i + r_X + \Delta d_i) / 3\} \\ &= \Sigma_{QX \in Ci} \{(b_X + g_X + r_X) / 3 + \Delta d_i\} \\ &= \Sigma_{QX \in Ci} (d_X + \Delta d_i) \\ &= \Sigma_{QX \in Ci} d_X + \Delta d_i \\ &= d_i + \Delta d_i \end{aligned} \tag{9}$$

[0046] As seen from the equations 6 through 9, in case of the average density information d_i of the space C_i being

greater than the target value T, the new average density information d_i' decreases with the amount of the variation Δd_i. In case the average density information d_i of the space C_i is less than the target value T, the new average density information d_i' increases with the amount of the variation Δd_i. The absolute value of the variation Δd_i increases as the average density information d_i of the space C_i deviates from the target value T.

[0047] Figure 6 shows the relationship between the average density information d_i of the space C_i and the new density information d_i' of the space C_i. In Figure 6, the solid line indicates the average density information d_i of the space C_i, and the broken line indicates the average density information d_i' of the space C_i. As indicated, the line indicating the average density information of the space C_i is moved in such a direction that a lighter density region becomes denser and a denser region becomes lighter.

[0048] Although in Figure 6, the new average density information d_i' is represented by the straight line, it is possible that a curve with a certain curvature may also represent it. For example, the curvature may be a cubic curve ($y=ax^3 + bx^2 + cx + d$, where a, b, c, d are constants).

[0049] In the case where an under exposed image or an over exposed image is photographed on the film, the image may not be able to be properly printed in a photographic paper. The reason why such a phenomenon occurs is that a region of the film characteristic with a bad linearity has been reached. Such a characteristic region is preferably multiplied by a coefficient to provide a pseudo linearity. For example, the color information (b_X, g_X, r_X) of the pixel P_X is preferably shifted so as to have an opposite characteristic of or against the film characteristic.

[0050] For example, for emphasizing the under exposed image photographed to the film, according to the following equations (10), the color information (b_X, g_X, r_X) of the pixel P_X may be updated to new color information (b_X', g_X', r_X'), and the density information d_X may be updated to the new density information d_X'.

$$d_X = (b_X + g_X + r_X) / 3 \tag{10}$$

$$sht = K_1 \times \ln (d_X) - K_2$$

$$b_X' = b_X + sht$$

$$g_X' = g_X + sht$$

$$r_X' = r_X + sht$$

$$d_X' = (b_X' + g_X' + r_X') / 3$$

where K_1 and K_2 are predetermined positive coefficients.

[0051] Then, it is possible to compensate the under exposed portion or the over exposed portion by adjusting the color information (b_X, g_X, r_X) and the density information d_X of the pixel P_X. Thereby, even if the film is photographed such that it is under exposed or over exposed, adjusting the time duration of printing the image photographed on the film to the photographic paper can be made unnecessary.

[0052] It is to be understood that although the present invention has been described with regard to preferred embodiments thereof, various other embodiments and variants may occur to those skilled in the art, which are within the scope and sprit of the invention, and such other embodiments and variants are intended to be covered by the following claims.

[0053] The text of Japanese priority application number 10-140291 is incorporated herein by reference.

Claims

1. An image processing method for image data containing pixels (P_x), said method comprising the steps of:

   dividing (S2) image data into a plurality of regions (A_1, A_2) based on color information of the pixels contained in the image data; and
   adjusting (S3, S4) density information of the pixels contained in at least one particular region.

2. The image processing method as defined in claim 1, wherein said step of dividing image data into the plurality of regions (A_1, A_2) includes comparing the color information of the pixels (P_x) with predetermined thresholds.

3. An image processing method for processing image data containing a plurality of pixels (P_x), comprising the steps of:

   mapping (S1, F) the plurality of pixels (P_x) into a plurality of points (Q_x) in a color space based on color infor-

mation (d_x) for each of the pixels (P_x);
detecting (S2 a plurality of spaces (C_i) contained in the color space (40) according to a concentration of the plurality of points (Q_x) in the color space (40);
adjusting (S3) average density information (d_i) of at least one particular space among the plurality of spaces (C_i); and
adjusting (S4) density information (d_x) of pixels (P_x) contained in the at least one particular space, based on the average density information (d_i) of the particular space.

4. The image processing method as defined in one of the claims 1-3, wherein said step of adjusting (S4) density information (d_x) further comprises the step of adjusting density information (d_x) of pixels (P_x) in a portion of the image data corresponding to at least one of an over exposed portion and an under exposed portion.

5. The image processing method as defined in claim 3 or 4, wherein said step of mapping includes mapping to a three dimensional color space (40).

6. The image processing method as defined in one of the claims 3-5, wherein said step of detecting a plurality of spaces (C_i) includes using predetermined, in particular six predetermined thresholds for each of the spaces.

7. An image processing apparatus for processing image data including pixels (P_x) comprising:

means for dividing (S2) the image data into a plurality of regions (A_1, A_2) based on color information of the pixels (P_x) in the image data; and
means for adjusting (S3, S4) density information of the pixels (P_x) in at least one particular region.

8. The image processing apparatus as defined in claim 7, wherein said means for dividing (S2) said image data comprises means for comparing the color information of the pixels (P_x) with predetermined thresholds.

9. An image processing apparatus for processing image data containing a plurality of pixels (P_x), comprising:

means for mapping (S1, F) the plurality of pixels (P_x) into a plurality of points (Q_x) in a color space (40) based on color information (d_x) of each of said pixels (P_x);
means for detecting (S2) a plurality of spaces (C_i) in said color space (40) according to densities of said plurality of points (Q_x) in said color space (40);
means for adjusting (S3) average density information (d_i) of at least one particular space from said plurality of spaces (C_i); and
means for adjusting (S4) density information (d_x) of pixels (P_x) in said at least one particular space based on said average density information (d_i) of said at least one particular space.

10. The image processing apparatus as defined in one of the claims 7-9, wherein said means for adjusting (S4) density information (d_x) of the pixels (P_x) further comprises means for adjusting density information of pixels (P_x) in a portion of said image data corresponding to at least one of an over exposed portion and an under exposed portion.

11. The image processing apparatus as defined in claim 9 or 10, wherein said color space (40) is a three dimensional space.

12. The image processing apparatus as defined in one of the claims 9-11, wherein said plurality of spaces includes predetermined, in particular six predetermined thresholds for each of the spaces.

Fig. 1

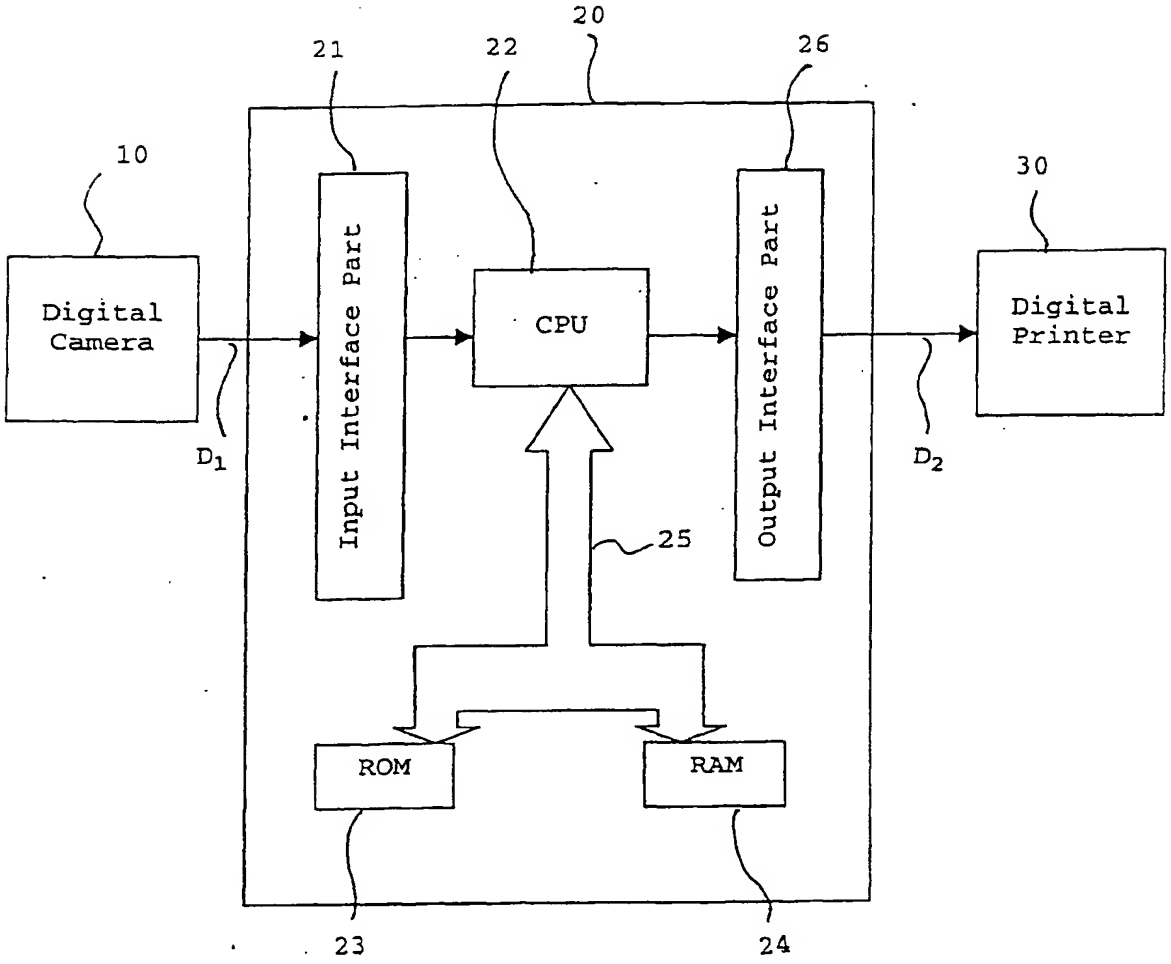
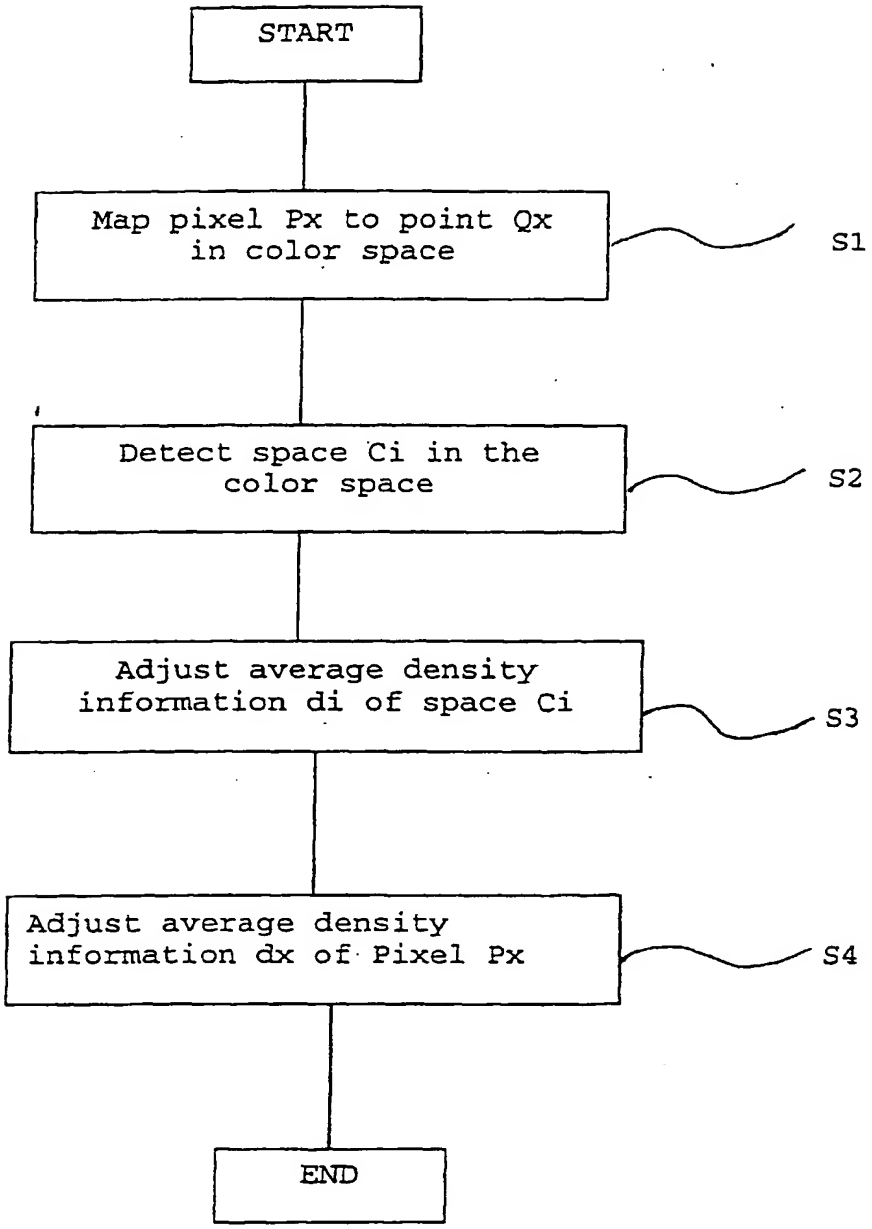

20
21
22
26
10
30
Digital Camera
Input Interface Part
CPU
Output Interface Part
Digital Printer
D_1
D_2
25
ROM
RAM
23
24

Fig. 2


START
Map pixel Px to point Qx in color space
S1
Detect space Ci in the color space
S2
Adjust average density information di of space Ci
S3
Adjust average density information dx of Pixel Px
S4
END

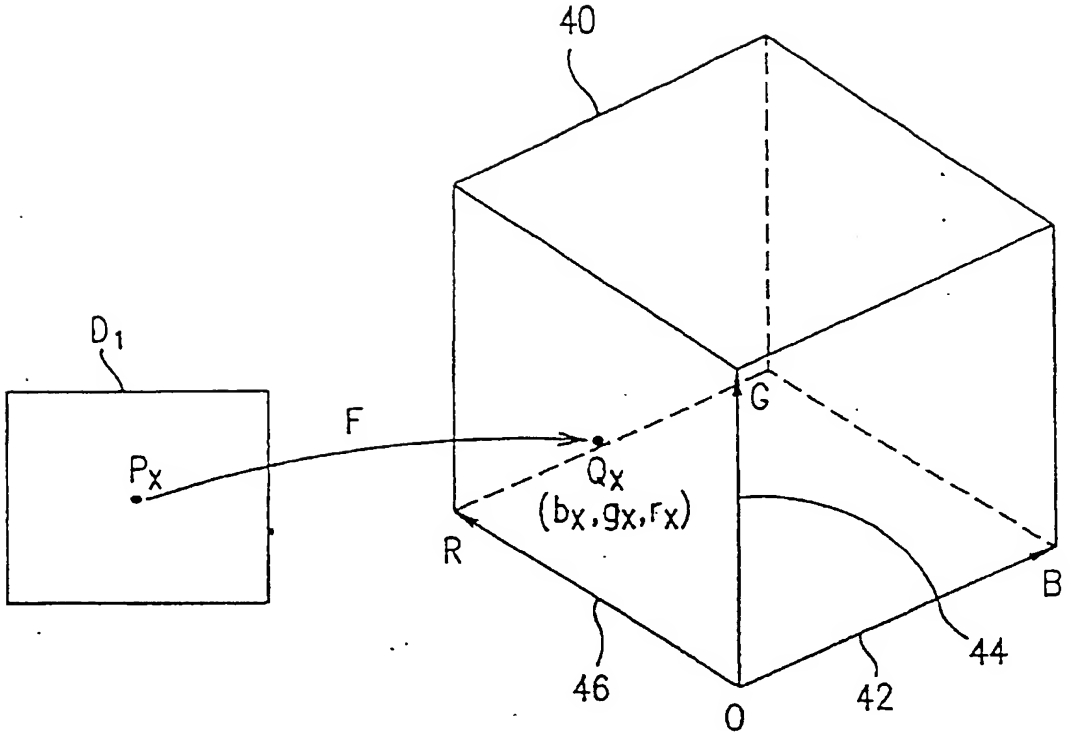


Fig. 3

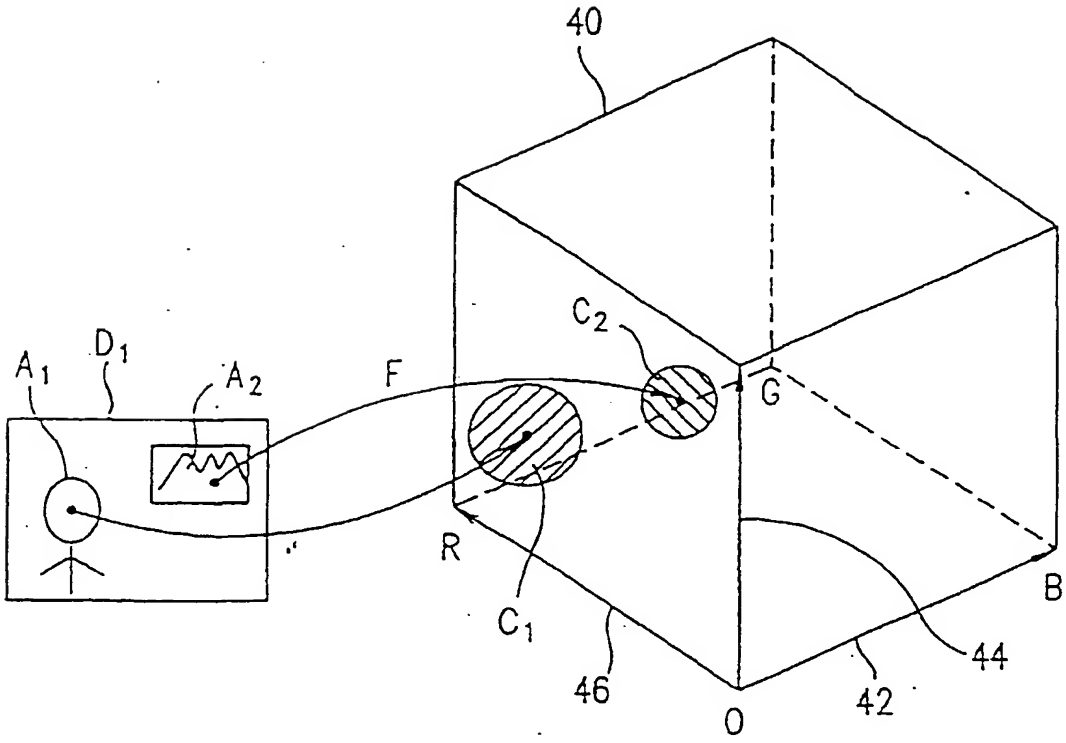


Fig. 4

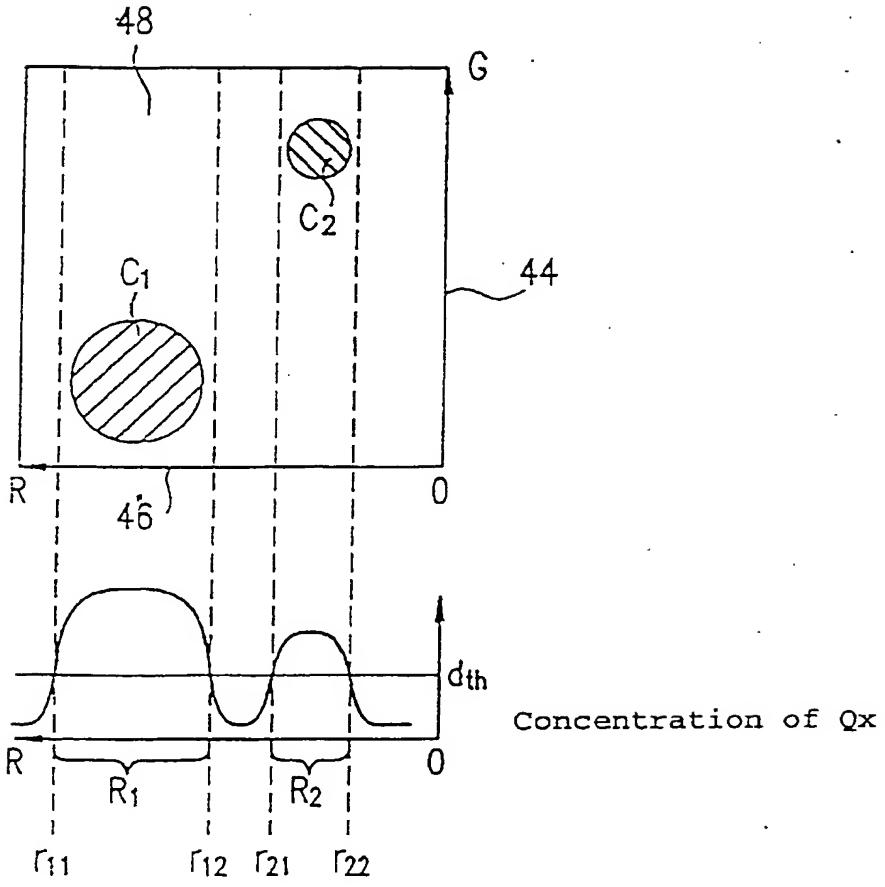

48
G
C2
C1
44
R
46
0
dth
Concentration of Qx
R
0
R1
R2
r11
r12
r21
r22

Fig. 5

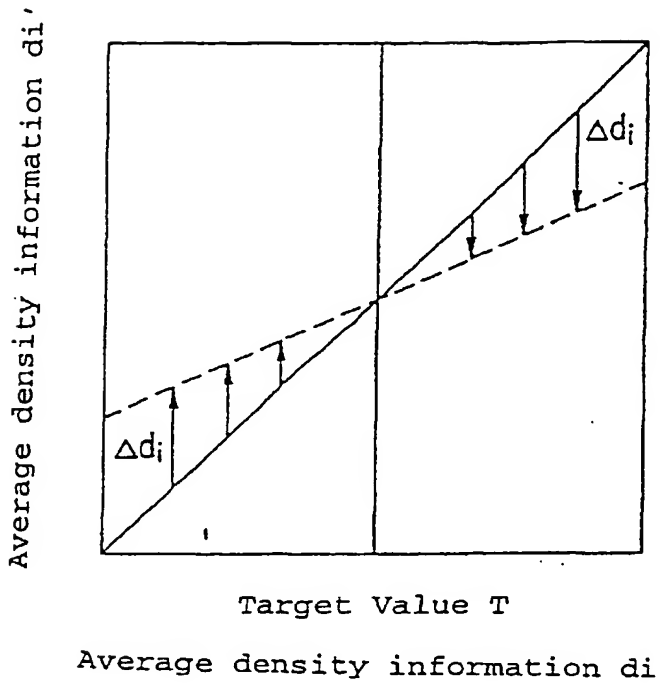

Average density information di'
Δdi
Δdi
Target Value T
Average density information di

Fig. 6